Claims

1. A method for producing an integrated optical waveguide with a patterned upper cladding comprising the steps of:

    a) depositing a core layer onto a substrate, optionally with a lower cladding layer therebetween;

    b) patterning the core layer to provide a light transmissive element;

    c) depositing an upper cladding layer onto the light transmissive element; and

    d) patterning the upper cladding to provide at least one region in which the light transmissive element is air clad.

2. A method according to claim 1 wherein the light transmissive element is air clad on at least one end.

3. A method according to claim 2 wherein the light transmissive element comprises a waveguide and lens as a unitary body.

4. A method according to claim 3 wherein the lens has an air clad curved surface.

5. A method according to claim 1 wherein the light transmissive element is air clad on at least one side.

6. A method according to claim 5 wherein the light transmissive element comprises a waveguide with a bend.

7. A method according to claim 6 wherein the waveguide has an air clad surface in the region of the bend.

8. A method according to claim 7 wherein the waveguide has an air clad surface on the side corresponding to the outside of the bend.

9. A method according to claim 1 wherein a portion of the upper cladding matches a portion of the light transmissive element.

10. A method according to claim 1 wherein a top portion of the light transmissive element is air clad.

11. A method according to claim 1 wherein the upper cladding layer comprises a polymeric material.

12. A method according to claim 11 wherein the polymeric material comprises a thermally curable polymer.

13. A method according to claim 12 wherein the thermally curable polymer is a siloxane polymer.

14. A method according to claim 11 wherein the polymeric material comprises a polymer curable by actinic radiation.

15. A method according to claim 14 wherein the actinic radiation is ultraviolet light.

16. A method according to claim 14, wherein the polymeric material is a siloxane polymer.

17. A method according to claim 1 wherein the upper cladding layer is patterned by selective curing with a patterned heat source and uncured material dissolved with a solvent, whereby cured material is insoluble in the solvent.

18. A method according to claim 1 wherein the upper cladding layer is patterned by selective curing with a patterned source of ultraviolet light and uncured material dissolved with a solvent, whereby cured material is insoluble in the solvent.

19 A method according to claim 1 wherein the substrate comprises silicon, quartz, fused silica, glass, or a polymeric material.

20. A method according to claim 19 wherein the polymeric material comprises an acrylate, Perspex, polymethylmethacrylate, polycarbonate, polyester, polyethyleneterephthalate or PET.

21. A method according to claim 1, wherein the lower cladding layer, where present, and light transmissive element comprise materials selected from polymeric materials, glass and semiconductors.

22. A method according to claim 21, wherein the polymeric materials comprise a polymer curable by actinic radiation.

23. A method according to claim 22, wherein the actinic radiation is ultraviolet light.

24. A method according to claim 22, wherein the polymeric material is a siloxane polymer.

25. An integrated optical waveguide with patterned upper cladding comprising:
a substrate;
an optional lower cladding layer;
a light transmissive element; and
a patterned upper cladding having at least one air clad region.

26. An integrated optical waveguide according to claim 25 wherein the light transmissive element is air clad on at least one end.

27. An integrated optical waveguide according to claim 26, wherein the light transmissive element comprises a waveguide and lens as a unitary body.

28. An integrated optical waveguide according to claim 27, wherein the lens has an air clad curved surface.

29. An integrated optical waveguide according to claim 25 wherein the light transmissive element is air clad on at least one side.

30. An integrated optical waveguide according to claim 29, wherein the light transmissive element comprises a waveguide with a bend.

31. An integrated optical waveguide according to claim 30, wherein the waveguide has an air clad surface in the region of the bend.

32. An integrated optical waveguide according to claim 31, wherein the waveguide has an air clad surface on the side corresponding to the outside of the bend.

33. An integrated optical waveguide according to claim 25 wherein a portion of the upper cladding matches a portion of the light transmissive element.

34. An integrated optical waveguide according to claim 25 wherein a top portion of the light transmissive element is air clad.

35. An integrated optical waveguide according to claim 25, wherein the upper cladding comprises a polymeric material.

36. An integrated optical waveguide according to claim 35, wherein the polymeric material comprises a thermally curable polymer.

37. An integrated optical waveguide according to claim 36, wherein the thermally curable polymer is a siloxane polymer.

38. An integrated optical waveguide according to claim 35, wherein the polymeric material comprises a polymer curable by actinic radiation.

39. An integrated optical waveguide according to claim 38, wherein the actinic radiation is ultraviolet light.

40. An integrated optical waveguide according to claim 39, wherein the polymeric material is a siloxane polymer.

41. An integrated optical waveguide according to claim 25, wherein the upper cladding is patterned by selective curing with a patterned heat source and uncured material dissolved with a solvent, whereby cured material is insoluble in the solvent.

42. An integrated optical waveguide according to claim 25, wherein the upper cladding is patterned by selectively curing with a patterned source of ultraviolet light and uncured material dissolved with a solvent, whereby cured material is insoluble in the solvent.

43. An integrated optical waveguide according to claim 25, wherein the substrate comprises silicon, quartz, fused silica, glass, or a polymeric material.

44. An integrated optical waveguide according to claim 43, wherein the polymeric material comprises an acrylate, Perspex, polymethylmethacrylate, polycarbonate, polyester, polyethyleneterephthalate or PET.

45. An integrated optical waveguide according to claim 25 wherein the lower cladding layer, where present, and light transmissive element comprise materials selected from polymeric materials, glass and semiconductors.

46. An integrated optical waveguide according to claim 45, wherein the polymeric materials comprise polymers curable by actinic radiation.

47. An integrated optical waveguide according to claim 46, wherein the actinic radiation is ultraviolet light.

48. An integrated optical waveguide according to claim 47, wherein the polymeric material is a siloxane polymer.

49. A method of fabricating an optical waveguide device with a patterned upper cladding, comprising the steps of:

a) forming a patterned blocking layer opaque to a predetermined wavelength on a portion of a substrate transparent to the predetermined wavelength;

b) depositing a core layer on said patterned blocking layer and/or on an uncovered portion of the substrate;

c) patterning the core layer from above to provide a light transmissive element;

d) depositing an upper cladding layer, which comprises a material curable by exposure to light of the predetermined wavelength, on the light transmissive element and/or on the patterned blocking layer and/or on an uncovered portion of the substrate;

e) irradiating said upper cladding layer from below with light of the predetermined wavelength, to cure those portions of said upper cladding layer not positioned above said patterned blocking layer; and

f) removing non-cured portions of said upper cladding layer.

50. A method of fabricating an optical waveguide device with a patterned upper cladding, comprising the steps of:

a) forming a patterned blocking layer opaque to a predetermined wavelength on a portion of a substrate transparent to the predetermined wavelength;

b) depositing a lower cladding layer on said blocking layer and/or on an uncovered portion of said substrate;

c) depositing a core layer on said lower cladding layer;

d) patterning the core layer from above to provide a light transmissive element;

e) depositing an upper cladding layer, which comprises a material curable by exposure to light of the predetermined wavelength, on said light transmissive element and/or on an uncovered portion of said lower cladding;

f) irradiating said upper cladding layer from below with light of the predetermined wavelength, to cure those portions of said upper cladding layer not positioned above said patterned blocking layer; and

g) removing non-cured portions of said upper cladding layer.

51. A method according to claim 49 wherein the substrate comprises silicon, quartz, fused silica, glass, or a polymeric material.

52. A method according to claim 51, wherein the polymeric material comprises an acrylate, Perspex, polymethylmethacrylate, polycarbonate, polyester, polyethyleneterephthalate or PET.

53. A method according to claim 49 , wherein the patterned blocking layer is formed by screen printing.

54. A method according claim 49 wherein the upper cladding layer comprises a polymer curable by exposure to light of the predetermined wavelength.

55. A method according to claim 54, wherein the predetermined wavelength is in the ultraviolet region.

56. A method according to claim 55, wherein the polymer is a siloxane polymer.

57. A method according to claim 49, wherein the patterned blocking layer comprises a compound that absorbs light of the predetermined wavelength.

58. A method according to claim 49, wherein the patterned blocking layer comprises a pattern of scattering surfaces, wherein the scattering surfaces scatter light of the predetermined wavelength, effectively blocking transmission of said light.

59. A method according to claim 58, wherein the scattering surfaces are produced by mechanical abrasion.

60. A method according to claim 58, wherein the scattering surfaces are produced by chemical etching.

61. A method of fabricating an optical waveguide device with a patterned upper cladding, comprising the steps of:

a) depositing a lower cladding layer on a substrate transparent to light of a predetermined wavelength;

b) forming a patterned blocking layer opaque to light having the predetermined wavelength on said lower cladding layer;

c) depositing a core layer on said blocking layer and/or on an uncovered portion of the lower cladding layer;

d) patterning the core layer from above to provide a light transmissive element;

e) depositing an upper cladding layer, which comprises a material curable by exposure to light of the predetermined wavelength, on said light transmissive element and/or on said blocking layer and/or on said lower cladding layer;

f) irradiating said upper cladding layer from below with light of the predetermined wavelength, to cure those portions of said upper cladding layer not positioned above said patterned blocking layer; and

g) removing non-cured portions of said upper cladding layer.

62. A method according to claim 61, further comprising the steps of:

i) forming a lift-off layer after forming the patterned blocking layer and before depositing the lower cladding layer; and

ii) removing the lift-off layer after removal of the non-cured portions of said upper cladding layer, to separate the lower cladding layer, light transmissive element and patterned upper cladding from the substrate.

63. A method according to claim 61, further comprising the steps of:

i) forming a lift-off layer on the substrate before depositing the lower cladding layer; and

ii) removing the lift-off layer after removal of the non-cured portions of said upper cladding layer, to separate the lower cladding layer, patterned blocking layer, light transmissive element and patterned upper cladding from the substrate.

64. A method according to claim 61, wherein the substrate comprises silicon, quartz, fused silica, glass, or a polymeric material.

65. A method according to claim 64, wherein the polymeric material comprises an acrylate, Perspex, polymethylmethacrylate, polycarbonate, polyester, polyethyleneterephthalate or PET.